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Extending the performance of industrial activated sludge plants.

The activated sludge process, in its various guises, is still probably the most common of all the aerobic processes used by industry for wastewater treatment today. Reliable and robust, it can be if well designed; flexible to a point within the original design capability but future proof was perhaps too much to expect. However recent combinations of oxygen transfer and biomass separation can give a new extended life and offer increased performance for existing stretched assets.

Characterised by a variety of devices for oxygen transfer from mechanical surface aerators, diffused air systems to jet aerators, wastewater treatment processes always require a means of biomass separation from the treated wastewater; traditionally this role being fulfilled by a gravity clarification stage, .

The original plant designs would have assumed a maximum COD load upon which the aeration system was based and a peak hydraulic flow which dictated the settlement stage design. The whole giving the required final effluent quality or expected performance to meet consent conditions at the time.

Industrial, economic and political change, however, is continuous and it is highly likely that numerous events will result in a completely different level of performance being demanded of a company's wastewater treatment facility during its lifetime.

These changes include increased factory output leading to higher water use or increased COD load applied, higher cost of trade effluent treatment and water supply, availability of water supply and discharge volume, power price increase and not least the focus on tighter consent conditions and compliance. Industry is also keen to demonstrate high environmental credentials particularly in the areas of carbon and water footprint and all in the current climate of austerity and difficult investment conditions.

It is often the case that the required performance becomes far beyond the original plant design capability, sometimes to the point where serious consideration is given to a complete new build or the addition of extra treatment capacity. This is not always necessary if recent developments in watertreatment technology are considered as a retrofit to the existing assets.

Technology improvements

BOC over the last three decades has successfully upgraded numerous activated sludge plants both in the municipal and industrial sectors using the Vitox system to overcome the oxygen transfer limitations of existing aeration devices. Additionally many purpose-built pure oxygen activated sludge plants have enabled industry to take performance beyond the normal "air" designs of organic load treatment, but optimum performance has always been limited by the hydraulic loading onto the inflexible settlement stage.

Retro-fitting a Vitox system to an existing aeration plant to cater for an increase in COD load requires a degree of flexibility in the settlement stage if the mixed liquor concentration needs to rise in order for the plant to operate at the same sludge loading or F/M ratio. Usually the improvement in sludge settlement, by virtue of being able to satisfy biomass oxygen requirements, allows for marginal increases in MLSS concentration.

The concentration of biomass which pure oxygen plants are able to support is far higher than the air norm, quite often in the range 10-15 kg/m^3; therefore this leads to the need for larger clarifiers. Thus the clarifier design becomes the rate limiting factor in a hydraulic capacity increase of conventional activated sludge plants.

Options could include building further settlement capacity and/or additional aeration capacity both significant and potentially expensive civils projects which require more space.

More recently a further option from BOC, which replaces and improves upon the settlement stage as well as increasing the organic load handling capacity, has become available.

Over the last 5 years BOC has been working on the incorporation of the crossflow membranes into the patented oxy/air sidestream process Vairox; this is a development of the Vitox pure oxygen process. This has culminated in the AXENIS™ process, a unique system which provides a means of oxygen transfer, pH control by air stripping CO_2, UF membrane separation of biomass together with some mixing energy as the biomass retentate is delivered back into the bioreactor.

This Oxy-Air MBR process can therefore operate at elevated dissolved oxygen levels (3-5mg/l), at slightly elevated temperatures because of better heat retention and optimal accurately controlled pH levels. This ensures a robust biological and membrane performance with lower surplus sludge production compared to similar plants operating at lower temperatures.

The whole process can be easily containerised and is aimed at providing an easily integrated and substantial upgrade to any industrial aeration plant, as it can include the required additional oxygen transfer as well as the means of biomass separation. The overloaded settlement tanks become redundant and the process becomes an Oxy/air MBR capable of operating at between 15 to 25 kg/m^3 biomass concentration. Typical increase in performance can be upto 100% in both flow and load. This will depend on ultimate biodegradability, on food wastes upto 99.5% COD removal has been seen and with suspended solids down to <3mg/l in the UF permeate (final effluent).

A containerised pilot plant has been built in order to demonstrate the potential performance of the process both in terms of biological and membrane performance.

The quality of the final effluent or UF permeate can be suitable for a river discharge consent subject to Environment Agency permissions, or to enable water recycle options to be evaluated. The UF permeate is an ideal feed to an RO plant which will produce water of a standard which meets the UK Water Supply (Water Quality) Regulations and therefore can be blended back into the incoming water supply to a factory. An increasing number of major food retailers are benefiting from such systems. Any project which enables >40% water re-use can also qualify for an Enhanced Capital Allowance, a scheme introduced by the Government in 2005.

The process which is suitable to upgrade any existing activated sludge plant, whether in the food, chemical, pharmaceutical or paper industries, has been trialled on a number of different waste streams during the process development, these are summarised below.

Sector	COD in	COD out	UF BOD	UF SS	Operating MLSS	Potential capacity increase
Dairy	12,000	<50	<3	<3	20-25,000	No existing plant
Food	4,400	130	19	9	21,000	No existing plant
Vegetable (Installed 09)	16,000	80	n/a	<5	14,000	100% COD load achieved
Salads	710	57	n/a	<5	18,000	30% COD load
Chemical1	4000	1700 (hard COD)	n/a	78	18-25,000	50-100% COD load

All figures in mg/l

The demonstration facility, which can be hired from BOC, incorporates a 4 m^3 bioreactor and the ability to vary the ratio of oxygen and air for oxygen transfer. Two UF Crossflow membrane modules provide the separation and can be used independently, in series or parallel to cover all potential process designs.

A laboratory workbench at one end of the container enables BOC to provide the basic chemical analysis as part of the evaluation. The pilot plant was built for BOC by Aquabio Ltd with whom BOC work with on potential projects.

The evaluation is translated into the design of a containerised AXENIS™ solution which just requires a concrete pad on the customer's site near to the bioreactor and pipework interconnection, the footprint of which is much less than the space occupied by the conventional clarifiers.

Typically there may be the requirement for some additional fine screening to protect the membrane system, but the majority of the existing aeration plant can be utilised – the bioreactor, possibly some of the aeration equipment and any upfront settlement or solids removal system which is, of course, still important.

The objective, however, is to provide a Turnkey solution which minimises the capital expenditure which would have otherwise been required extending or building a new plant. This is delivered with the minimum of disruption and without the requirement for any further space while providing increased wastewater treatment capacity to a higher standard with the option of water re-cycling.

This results in the client achieving savings in both trade effluent charges (in relation to volume, COD and SS) and potentially in water supply costs based on reduced usage.

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